

THE APPRENTICE'S COMPANION. L. C.

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(Continued from our last number.)

A space or flat surface, enclosed by three lines, is the most simple of all definite figures, and is called a triangle. Among the varieties of these figures are the rectangular triangle, so named because it has one right angle; the equilateral triangle, which has three sides of equal extent; the isosceles triangle, which has only two equal sides; and the scalene triangle, all the sides of which are of different lengths. Any space enclosed by four lines is called a quadrilateral, or four-sided figure. Among such are included the square, having four equal sides and right angles; the rectangle, or oblong square, having only the opposite sides equal; the lozenge, which has equal sides, and unequal angles; and the trapezium, which has only two of its sides parallel. When the sides of a quadrilateral figure are parallel, it is termed a parallelogram. A line joining two opposite or alternate angles, is called a diagonal. Any figure having several angles, and, consequently, several sides, is named a polygon.

Solid figures include the tetraedon, or four-sided solid, which is the most simple figure of the kind, as no solid can have less than four sides; and when the number of sides is greater, the figure is called either a hexagon, an octagon, an icosaedron, or a polyedron, according to the number of its sides.

Among polyedrons may be distinguished the prism, formed of parallelograms only, or of parallelograms and two polygons of any number of sides. Among the prisms may be specified the parallelopiped, formed of six parallelograms only; and among the parallelopipeds may be noticed the cube, having six square sides. The pyramid is a polyedron, formed by a polygon of any kind as its base, and as many triangular planes as the polygon has sides: the point where all the triangular planes unite is called the summit of the pyramid. The most simple solid of this kind is the tetraedron, or four-sided pyramid, including the base.

The terms sphere, cylinder, and cone, designate solid figures, having either entirely or partially curved surfaces; and the expressions spheroid, cylindroid, and conoid, are used to denote solid figures, more or less resembling a sphere, a cylinder, or a cone, respectively.

Natural Philosophy is the science which

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explains the causes of the various properties of bodies in general, as shown by the changes which they undergo in any particular circumstances, or the changes which they may occasion in other bodies, under certain circumstances. The province of natural philosophy does not extend to the explanation of the doctrine of final causes, or the immediate and positive reasons why particular effects take place, or why certain bodies possess the peculiar properties with which they are endowed; but it enables us to appreciate the consequences of any body being placed in a given situation, or to foretell what will be the result of any body acting on another in a certain manner. Thus, we know nothing of the absolute cause of gravity or weight, which is that property of bodies in consequence of which they fall towards the surface of the earth, if raised in the air by any force and then dropped; but natural philosophy, while it leaves us in ignorance of the final cause of gravity, enables us to determine a vast variety of curious circumstances with respect to falling bodies. Thus, it is found that a heavy body, as, for instance, a marble or a musket-ball, dropped from the balcony of St. Paul's, would fall faster as it approached near to the ground than it would in passing through the former part of its descent; and the rate at which a body falls through a given space has been ascertained by experiment, and can be calculated with the utmost exactness. So as to the final cause of electric and magnetic attraction, various opinions have been advanced, and it is still involved in obscurity; but we know by experience, that a magnet attracts iron with considerable force, and that a thin bar of magnetic iron, accurately poised on its centre, will, when left free, point towards the north with one end, and towards the south with the other; and on the latter property depends the action of the mariner's compass, by means of which the sailor, crossing the pathless sea, is able to ascertain in what direction his vessel is steering; and to this little instrument, which was unknown to the ancients, we are in a great degree indebted for the important discoveries of modern navigators. Whether light and heat are owing to matter or motion, has been left among the questions which philosophy has hitherto been unable satisfactorily to decide; but the effect of light on bodies, whether opaque, transparent, or semi-trans-

parent, the velocity with which it passes through space, and the manner in which it is modified, by optical glasses of various forms, are among the numerous interesting and surprising properties of light, which natural philosophy has laid open to our investigation, and which we are enabled to verify and illustrate by means of mathematical calculation; and the phenomena of heat and cold, with which we are so intimately familiar, from the sensations they occasion, are equally hidden as to their final cause, and equally wonderful and curious as to their effects, the latter of which alone afford an ample field for the experiments and deductions of the philosophical inquirer.

Astronomy presents a boundless field for research, and notwithstanding it has been explored with signal success in modern times, yet the most important discoveries that have been made only serve most distinctly to evince that the wisest and most successful investigators of the phenomena of the science have merely entered on the confines of knowledge, and enabled us to form some imperfect estimate of those boundless regions which display an inexhaustible field for future speculation and inquiry. It has indeed been ascertained that the sun, and the planetary and other bodies which constitute the solar system, are influenced by the same moving power as that which causes the fall of an acorn to the ground, when detached from the oak on which it was produced; and that the attractive force which retains the moon in her orbit, and causes her re-action on the fluid parts of the terrestrial globe we inhabit, producing the tides, may be estimated with accuracy, and subjected to mathematical calculation. But there are numberless topics of inquiry—with regard to the constitution of the sun, the nature of comets, and the causes of their peculiar motions, the kind of medium which occupies the space beyond the atmospheres of the earth and planets, and the relations that may exist between our solar system and the numberless other systems, the existence of which may be inferred from the appearance of the starry heavens—which may for an indefinite period serve to exercise the talents of men of genius and learning, but concerning which we can hardly hope to attain any knowledge approaching to certainty, till discoveries and inventions in other sciences provide us with means for investigating the works of nature, as much superior to those which we at present possess as our instruments of research surpass those employed by the ancients.

"The proper business of philosophical inquiry," says Sir John Leslie, "is to study carefully the appearances that successively

emerge, and trace their mutual relations. All our knowledge of external objects being derived through the medium of the senses, there are only two ways of investigating physical facts—by *observation* or *experiment*. Observation is confined to the close investigation and attentive examination of the phenomena which arise in the course of nature; but experiment consists in a sort of artificial selection and combination of circumstances, for the purpose of searching minutely after the different results.

"The range of observation is limited by the position of the spectator, who can seldom expect to follow nature through her winding and intricate paths. Those observations are of the most value which include the relations of time and space, and derive greater nicety from their comprising a multiplied recurrence of the same events. Hence, Astronomy has attained a much higher degree of perfection than the other physical sciences.

"Experiment is a more efficient mean than observation for exploring the secrets of nature. It requires no constant fatigue of watching, but comes in a great measure under the control of the inquirer, who may often at will either hasten or delay the expected event. Though the peculiar boast of modern times, yet the method of proceeding by experiment was not wholly unknown to the ancients, who seem to have concealed their notions of it under the veil of allegory. *Proteus* signified the mutable and changing forms of material objects; and the inquisitive philosopher was counselled by the poets to watch that slippery dæmon when slumbering on the shore, to bind him, and compel the reluctant captive to reveal his secrets. This gives a lively picture of the cautious and intrepid advances of the skilful experimenter. He tries to confine the working of nature—he endeavors to distinguish the several principles of action—he seeks to concentrate the predominant agent—and labors to exclude as much as possible every disturbing influence. By all these united precautions, a conclusion is obtained nearly unmixed, and not confused, as in the ordinary train of circumstances, by a variety of intermingled effects. The operation of each distinct cause is hence severally developed."—[Introduction to Elements of Natural Philosophy.]

The object of Natural Philosophy may be stated to be the study of the general properties of unorganized bodies, or inert substances, in the state of *solids*, *liquids*, *airs*, or *gases*, and those which have been termed *incoercible* or *ethereal fluids*. It is also within the province of the physical sciences to examine the mechanical action which bodies in their different states may exercise

on each other, and the different circumstances connected with their movements.

The various effects of the motions and operations of bodies depending on their general properties have hence been made the foundation of several distinct sciences or branches of knowledge, which have been usually classed with reference to the several forms of matter called solids, liquids, and airs, or to certain kinds of phenomena, supposed to depend respectively on the presence and action of some imponderable modification of matter or ethereal fluid, to which have been referred thermometrical, optical, electrical, and magnetic phenomena. Hence, a treatise on Natural Philosophy may be conveniently arranged under the different departments of (1.) MECHANICS, or the doctrine of equilibrium and motion as respects solids, including Statics and Phoronomics or Dynamics; (2.) HYDROSTATICS, including Hydrodynamics or Hydraulics, relating to the equilibrium and motion of liquids; (3.) PNEUMATICS, including Aerostatics, and Aerodynamics, or the effect of forces on air and other gaseous fluids; (4.) ACOUSTICS, or the theory of sound, comprehending observations on musical and vocal sounds; (5.) PYRONOMICS, or the investigation of the causes and effects of heat, or more generally of change of temperature; (6.) PHOTONOMICS, or OPTICS, including the theory of light and vision; (7.) ELECTRO-MAGNETISM, which treats of the causes of electric and magnetic attraction and repulsion.

We acquire a knowledge of the properties of matter through our senses, either by immediate observation, or by experimental inquiry with the aid of instruments. The senses of sight and feeling afford us abundance of information concerning the properties of bodies around us, but our knowledge may be vastly extended when we assist the former by means of optical glasses, which open new worlds to our view, or when by means of delicate instruments we measure degrees of temperature, electricity, or magnetic power.

Solid bodies are those which, like stone or wood, present a sensible resistance when touched, pressed, or handled. They may be cut into various forms, and preserve without difficulty the figures which are given to them, or which they possess naturally. Sand, powders, and similar substances, consist of small particles not united together; yet, though collectively, masses of sand present but little resistance to pressure, the individual minute particles have all the characteristics of solid matter, and though readily dispersed by force, they may be assembled in heaps more or less considerable.

Liquid substances are those which, like water, manifest immediately to the touch

but a very feeble resistance, but quite sufficient to indicate their presence, even when in a state of repose. They cannot be grasped between the fingers like solid bodies, nor can they be collected in heaps, or made to take any particular figure, except that of the vessel in which they may be included.

Aeriform fluids are in general invisible bodies, which, like the air surrounding us, cannot be felt, and afford no evidence of their presence to the sense of touch, when in repose. But their existence is ascertained with abundant certainty when they are in motion; thus no one can doubt the materiality of atmospheric air after experiencing the violent exertion necessary in walking against a high wind. Aeriform bodies may be confined in vessels, whence they exclude liquids or other bodies, demonstrating their impenetrability, though they readily become compressible to a great extent, but there are limits beyond which it is impossible to reduce them.

Equality of Action and Re-action in the Collision of Bodies.

An experimental illustration of the equality of action and re-action in the collision of bodies may be thus exhibited:



Suppose *a* and *b* to be two inelastic balls,* suspended together at *c*, by threads of equal lengths, so that they may be in contact when at rest; and let *d e* be a graduated arch, over which the balls may oscillate freely; then, if the ball *b* be moved a certain number of degrees towards *e*, and let fall so that it may impinge on the ball *a*, both together will move towards *d*, through a number of degrees proportioned to their common velocity.

Since it appears from the foregoing observations to be an established principle of Mechanics, that the force or impetus of a body in motion is to be estimated by its mass and velocity, it must be concluded that a body, the mass of which is very inconsiderable, may be made to act with the same force as another body the mass of which is much greater, provided the smaller body has a velocity communicated to it greater than the velocity of the larger body, in the same proportion that the mass of the latter surpasses that of the former. Thus, a pin-cushion weighing half an ounce might produce as great an effect as a cannon-ball weighing thirty-six pounds, provided the

* No substance in nature is wholly destitute of elasticity; but soft clay, which is among the least elastic of solid bodies, may be used to make the balls for the above experiment.

pincushion had 1152 times the velocity of the cannon-ball; for 1152 half ounces being equal to 36 pounds, it must be obvious that the velocity of the pincushion would be just so much greater than the velocity of the cannon-ball, as the mass of the latter would be greater than that of the former.

Hence, as the momentum or effect of moving force is to be estimated by the velocity of the motion and the weight or mass of the moving body taken together, it may be perceived how it happens that a small mass may produce an extraordinary effect when moving with great velocity: thus, a tallow candle fired from a gun will pierce a deal board. On the other hand, a great effect may be produced by a small velocity, if the moving mass is extremely great: as, for instance, a heavily laden ship of great burden, afloat near a pier wall, may approach it with a velocity so small as to be scarcely observable, yet its force will be sufficient to crush a small boat.

When two bodies meet in consequence of moving from opposite directions, each body will sustain a shock as great as if one body at rest had been struck by the other with a force equal to the sum of both their forces. Suppose two persons of equal weight walking in opposite directions, one at the rate of two miles an hour, and the other at the rate of four miles, if they should suddenly come in contact, each would receive a shock as great as if he had been standing still, and another had run against him moving at the rate of six miles an hour. In the ancient tournaments, when mailed knights met in full career, prodigious must have been the shock when the collision was direct, and both would often be overthrown with a force proportioned to their joint weights and velocities. So when two vessels under sail run foul of each other, suppose one of them eight hundred tons burthen, and the other twelve hundred tons, their velocities or rates of sail being equal, each would sustain a shock equal to that which a vessel would receive if at anchor, and struck by another vessel of two thousand tons burthen, sailing at the same rate with the vessels in question. Yet though the shock would be the same, the consequences would be most disastrous to the smaller vessel, the other being protected in a greater degree from injury by its superior strength and bulk.

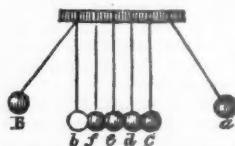
Elasticity being a common property of matter, and many substances employed for a variety of purposes, as several kinds of wood and metal, possessing that property in a high degree, its influence in modifying the operation of moving forces must not be neglected.

The different effects exhibited by bodies almost inelastic, and those which are highly elastic, may be illustrated by the simple ex-

periment of dropping a ball of soft clay or wax from any given height on a solid pavement, and then letting fall from the same height a ball of box-wood or ivory, of equal weight with the clay. The first ball will give way to the pressure of the pavement, and become dented or flattened on the side on which it rests, while the latter ball will rebound from the pavement with a force proportioned to the height from which it fell. This resiliency or rebound, in an ivory ball, is partly occasioned by its giving way to the pressure of the pavement; but, unlike the clay, it recovers its shape almost instantaneously, its surface thus acting as a spring against the pavement. That a hard substance like ivory is compressed by striking against a similar substance, may be shown by making a small dot with ink on the surface of one ball, and then bringing it gently in contact with another ball at that point, when a small mark will also appear on the latter ball; but if the balls, one being marked as before, be brought into contact with considerable force, as by pressure or collision, a much larger mark will be found on the latter ball than before; proving that, though both have recovered their shape, they must have undergone compression.

Let two ivory balls of equal weight, *a* & *b*, be suspended by threads, as in the annexed figure; if the former be then drawn aside to *c*, and suffered to fall against the latter, it will drive it to *d*, or

a distance equal to that through which the first ball fell; but it will itself rest at *a*, having given up all its own moving power to the second ball.



If six ivory balls, of equal weight be hung by threads of the same length, and the ball *a* be drawn out from the perpendicular, and then let fall against the second, that and the other three, *c* *d* *e* *f*, will continue stationary; but the last ball *b* will fly off to *B*, being the same distance as that through which the first ball fell. Here the motion, or rather the moving force, of the ball *a*, is propagated through the whole train to the ball *b*, which, finding no resistance, is acted on by the whole force. This experiment, repeated with any number of balls, would give the same result. It is proper to observe that, in stating the effect of the collision of the balls in these experi-

ments, they are supposed to be perfectly elastic bodies: such, however, do not exist among the substances with which we are acquainted; the phenomena exhibited by ivory balls would therefore be nearly, but not exactly, such as are stated.

The effect of elasticity in modifying the propagation of motion is curiously displayed in those exhibitions of human strength which have occasionally taken place, and of which remarkable instances are related by some authors. Vopiscus, the Roman historian, mentions a circumstance of this kind, in his Life of Firmus, who, in the reign of Aurelian, endeavored to make himself emperor in Egypt, and who has therefore been reckoned one of the Thirty Tyrants. He was a native of Seleucia, in Syria, who espoused the cause of the famous Zenobia, Queen of Palmyra; and having been taken prisoner, he was executed by order of the emperor Aurelian. The historian says of Firmus, that he was able to bear an anvil on his breast, while others were hammering on it; he lying along, with his body in a curved position. And Beckmann, in his History of Inventions, notices the extraordinary feats of John Charles Von Ekeberg, a German, who travelled over Europe about the beginning of the last century. After mentioning other feats, he adds, "But what excited the greatest astonishment was, that he suffered large stones to be broke on his breast with a hammer, or a smith to forge iron on an anvil placed upon it."* A part of the mysterious effect produced in these cases is to be accounted for by the position of the exhibitor, which may be thus described: He must place himself with his shoulders resting on one chair, and his feet upon another, both chairs being fixed so as to yield firm support; and thus, his back-bone, thighs, and legs, would form an arch, of which the chairs would be the abutments. The anvil, also, must be so large, as, by its inertia and elasticity, nearly to counterbalance the force of the hammer, and thus the strokes would be scarcely or not at all felt; besides which, the elasticity of the man's body, as well as his position, would contribute to his security against the effect of the blows.

Velocity of Moving Bodies.

Communication of motion, however rapid, must take up some portion of time; for, as there can be no such thing as instantaneous motion, much less can motion be propagated instantaneously from one body to another. Hence, motions performed with great velocity sometimes produce peculiar effects, as may be shown by the following experiments:

Experiment I.—A long hollow stalk or reed, suspended horizontally by two loops of single hairs, may, by a sharp quick stroke at a point nearly in the centre, between the hairs, be cut through, without breaking either of them. The hairs, in this case, would have been ruptured, if they had partaken of the force applied to the stalk; but the division of the latter being effected before the impulse could be propagated to the hairs, they must consequently remain unbroken.

Experiment II.—A smart blow, with a slight wand, or hollow reed, on the edge of a beer-glass, would break the wand, without injuring the glass.

Experiment III.—A shilling, or any small piece of money, being laid upon a card placed over the mouth of a tumbler glass, and resting upon the rim of the glass, the card may be withdrawn with such speed and dexterity that the piece of money will not be removed laterally, but will drop into the glass.

Experiment IV.—A bullet discharged from a pistol, striking the panel of a door half open, will pass through the board, without moving the door; for the velocity of the bullet will be so great that the aperture is completed in a space of time too limited to admit of the momentum of the moving body being communicated to the substance against which it is impelled.

It is an effect of the principle just illustrated, that the iron head of a hammer may be driven closer on its wooden handle, by striking the opposite end of the handle against any hard substance with force and speed. In this very simple operation, more easily conceived than described, the motion is propagated so suddenly through the wood that it is over before it can reach the iron head, which, therefore, by its own weight, sinks lower on the handle at every blow, which drives the latter up.

The velocity of motion is measured by time and space taken conjointly or relatively. Thus, a body moving through a given space, in a certain time, and supposed to pass through every part of that space at a uniform rate, is said to move with a velocity denoted by the ratio of the time to the space; and, therefore, a uniformly moving body will describe equal spaces in equal times, and different bodies relative spaces in relative times. Hence, a horse that will trot eight miles in an hour, would trot sixteen miles in two hours, and twenty-four miles in three hours, if he could traverse the distance with unabated speed. If, in this case, the three distances mentioned be considered as three distinct journeys, it will readily be perceived that the horse must have passed through the same distance in each of the two hours of the second journey, and each of the three hours of the third

* Hist. of Invent., Eng. Trans. 1797, vol. iii. p. 303.

journey, as in the single hour of the first; and this is what is meant by the statement that equal spaces are passed over in equal times; so that when the distance travelled is doubled or tripled, the time will be doubled or tripled also; and if the distance is reduced to one-half or one-fourth, the time will be reduced in the same proportion. The relative velocities of different bodies must be estimated in a similar manner. A man walking three miles in an hour would require double the time to perform a journey of eighteen miles, that would be taken up by another man running six miles an hour; and a horse galloping twelve miles an hour would complete the journey in one-fourth of the time of the first man, and one-half the time of the second man. The minute-hand of a common clock or watch has twelve times the velocity of the hour-hand, since the former passes through a whole circle, while the latter is passing through the twelfth part of it.

The velocity of a uniformly moving body may be discovered by dividing the space passed through by the time consumed: thus, the velocity of a steam-boat, going eighteen miles in two hours, will be found to be nine miles an hour. The velocity being known, the distance passed over in a given time may be discovered, by the contrary operation of multiplying the space by the time: thus, the steam-boat, with a velocity of nine miles an hour, will of course run twice nine miles in two hours, and forty-eight times nine miles in forty-eight hours.

Different Kinds of Motion.

Motion may be uniform or variable with respect to its rate or relative velocity. The nature of uniform motion has been just pointed out; and that of variable motion will be subsequently investigated. But motion may be different in one case from what it is in others, when considered with regard to the manner in which a body moves: as whether in a straight line, in a circle, or in any other curve. The line described by a body, in passing from one point to another, is called its direction or line of motion. The direction of a moving body may be either a right line, across a level surface or plane; a curved line, passing over a similar plane; or a curved line, the different parts of which are not on one plane.

Curvilinear motion is of a more complicated nature than motion in a straight line, the circumstances relating to it therefore cannot be properly explained without a previous investigation of rectilinear motion.

Sir Isaac Newton, in his great work entitled "*Principia Philosophiæ Naturalis*,"—"*Principles of Natural Philosophy*,"—has laid down three general positions, styled

Laws of Motion, which have been considered as the foundation of mechanical science. These laws are the following:

"1. Every straight body must continue in its state of rest, or of uniform motion in a straight line, unless it be compelled to alter its state of rest or motion, by some force or forces impressed upon it."

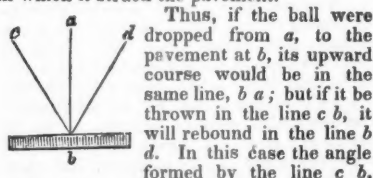
"2. Every change of motion must be proportional to the impressed force or forces, and must be in the direction of that force."

"3. Action and re-action are always equal and contrary to each other."

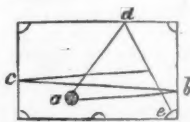
Both the first and the last of these laws or positions, relating to moving bodies, have been already discussed, and their consequences pointed out: they may therefore be admitted as propositions not requiring farther demonstration.

The second law of motion is of the highest importance, as it relates to compound motion, and the direction of a body acted on by two forces in different but not contrary directions. The effect of forces thus applied will be most readily understood after a short explanation of the nature of reflected motion, which affords a familiar example of action and re-action, the subject of the third of the preceding laws.

If a cricket-ball, or any similarly shaped elastic body, be dropped perpendicularly on a smooth pavement, it will rebound to a certain point in the same straight line in which it descended; but if it be impelled obliquely against the pavement, it will not rise in a perpendicular line, but in a line having the same degree of obliquity as that in which it struck the pavement.



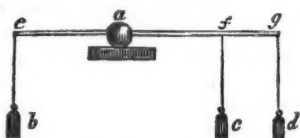
Thus, if the ball were dropped from *a*, to the pavement at *b*, its upward course would be in the same line, *b a*; but if it be thrown in the line *c b*, it will rebound in the line *b d*. In this case the angle formed by the line *c b*, with the line *a b*, is called the "angle of incidence," and that formed by the line *d b*, with the line *a b*, the "angle of reflection;" and it is to be observed that these angles will always be precisely equal. For it signifies not whether the obliquity of the line of incidence be great or small, since the line of reflection will in every case have the same obliquity, and consequently form a similar angle with the surface from which the body rebounds.



Suppose the parallelogram in the margin to represent a billiard-table: if a ball standing on it be impelled in the direction *a b*, it will

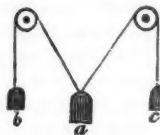
strike against the end cushion and return in the line $b c$, and either of those lines would form a similar and very acute angle with a line drawn between them, parallel to the sides of the table; but if the ball were driven from a against the side cushion at d , it would return in the corresponding line $d e$.

Equal weights, or equal forces of any kind, acting on a body, in a similar manner, but in opposite directions, will keep it in a state of rest, or equilibrium, like the scales of a common balance, each loaded with a weight of one pound. But when the arms of a balance are of unequal lengths, as in the steelyard, a small weight fixed at the end of the longest arm will counterpoise a much greater weight at the end of the short arm.



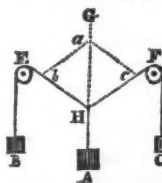
Let a represent a globe of lead resting on a level surface, and having an iron rod passing exactly through its centre, the extremities of which, e and f , are equidistant from the ball; if thread of equal lengths be fixed at those points with hooks at the lower ends for the suspension of weights, the globe and rod will be kept in equilibrium so long as the weights b and c are equal; but if a longer rod be passed through the ball, projecting farther from it towards g than towards e , a smaller weight d will then counterbalance the weight b , and the relative number of ounces or pounds contained in these weights will always bear certain proportions to the number of inches or feet in the respective parts of the rod $e f$, and $e g$.

Here the equilibrium is maintained by equal forces acting in opposite directions; and the illustration of this simple principle is deserving of attention, as it leads to the consideration of the case of equilibrium maintained by the application of three forces.



In the annexed figure the weight a being attached to the centre of a cord passing over two small wheels, and the weights b and c to either end of the cord, the equilibrium will be maintained only while the central weight counterbalances those at the ends, in order to which, exclu-

sive of the effect of friction, the weight a must be just as heavy as the equal weights b and c taken together. For if the weight a be much increased, the cord will sink in the centre, and the weights b and c be drawn up to the wheels; and the weight added on either side will drag down the cord on the side of the additional load and raise the central and opposite side weight.



Suppose a cord, as in the marginal figure, stretched over the wheels $E F$, attached to an upright board, and having fixed to its extremities the weights $B C$. From any part of the cord, between the wheels, as at H , let a weight A , be suspended; it will then draw down the cord so as to form an angle, $E H F$, and the weights will remain in equilibrium. It is obvious, that in this case the weight A , acting in the direction $H A$, will counterbalance the weights B and C , acting in the directions $H E$ and $H F$, and their joint forces must be equivalent to a force equal to A acting in the direction $H G$. To ascertain the relative effect of the weights thus operating, it will be necessary to complete the figure, by drawing on the board the dotted line $H G$, in the direction of the cord $A H$; and lines under the cords $H E$ and $H F$. Then on the line $H G$ mark the point a , and $H a$ must be supposed to represent as many inches as the number of ounces contained in the weight A . From a draw the dotted line $a b$, parallel to $H F$, and the dotted line $a c$, parallel to $H E$; then if the diagram were in the proportion just described, the line $H b$ would contain as many inches as there were ounces in the weight B ; and the line $H c$ as many inches as the number of ounces in the weight C . A moment's reflection will show that the relative weights and lengths might consist of any denominations of weight and longitudinal measure; so that feet and pounds, or any greater or smaller denominations, might have been substituted for inches and ounces; only in every case the same denomination of longitudinal measure must be applied to all the lines, and the same denominations of weight to all the gravitating forces.

The case just considered affords an experimental illustration of what is called the parallelogram of forces, a principle of the utmost importance in mechanics, since it enables us to estimate the joint operation of moving powers, as well as their relative effect or influence.

In the preceding diagram, the parallelo-

gram of forces is represented by the lines $a b$, b , H , $H c$, and $c a$, and the line $H a$, joining the opposite angles, which is called the diagonal. The sides of the parallelogram, $a b$ and $a c$, will represent the quantity and direction of the two forces acting together, and the diagonal $H a$ will denote the equivalent or counterbalancing force. This last force is styled the resultant, and the two forces opposed to it are its components.

(To be continued.)

[For the Apprentice's Companion.]
CAPITAL.

Ah! but he has no capital to begin with! Very often, very often we hear this said; and uttered in such piteous tones, that we are in such cases almost tempted to ask, what extraordinary and melancholy destination does this young man, who is thus compassionated, labor under; or what singular calamity has befallen him, that he is thus held up as the victim of misfortune?

He has ordinary talents and capacity for labor; he has health and strength; he has enjoyed and improved the advantages of a useful education; he has acquired, or is in the way of acquiring, a respectable and good trade; he is not the slave of any bad habits; and above all things his character is good, and he has lived without reproach. But because he has no *monied* capital, you choose to pity him: now I entreat you, reserve your compassion for some more worthy object. He does not demand your pity half so much as your congratulation. He is much more an object of envy than of pity. "But he has no capital." Now what is capital? In respect to trade, or the business of acquiring wealth, capital is the means or instrument of acquisition and accumulation, and is generally applied to the money or property on hand not required to be consumed for immediate subsistence, but which we can use or apply for the purposes of begetting more. In an agricultural view, land which we may render productive by cultivation, or the seed which we cast into the ground, and which, under favorable circumstances of situation, season, and culture, will multiply and return to us very often a hundred or a thousand fold, is capital. In a com-

mercial view, capital is property beyond the wants of immediate subsistence, which you can invest in goods or articles of trade, and hold them in your possession, until under favorable circumstances you can sell, or exchange, and realize the profits of such adventure. Capital, in short, is money on hand, or the reserved profits of former labor, and speculation, or trade, which you can use for other and further purposes of trade and accumulation, and be able to wait its returns. But there is much other capital besides land or money. Every means of accumulation should be considered as so much capital. There is another agent in trade of equal power, as a means of accumulation, as money, and that is credit. This is often even far better than a monied capital. This will enable you, as far as you ought to desire it, to command the monied capital of other men, as if it were your own, and to use it for your benefit and theirs; and where it is based upon those substantial qualities of character, which form the only just and sure foundation of credit,—namely, truth, honor, industry, frugality, exactness, or punctuality,—it may be used with equal success and propriety as the instrument of accumulation, as the heaped up thousands which lay in the coffers of the most affluent.

Every thing in relation to matters of trade, and the pursuits of wealth, which is a means of accumulation, is capital. Now let us see, then, with what propriety it can be said of this young man of whom we have spoken, though he has no money at his entrance into life, that he has no capital; or rather, let us see what renders him an object of compassion.

He has youth, health, and ability. These all enable him to labor, and labor will command its reward. He has habits of frugality, which will lead him to expend carefully, and lay up the surplus wages of labor,—that is, the surplus beyond his immediate necessities. He has the elements of a good education; this furnishes him the means of acquiring more knowledge, and knowledge is always power. He has an art or trade; and this gives him an immense advantage, and puts it in his power to apply his labor and faculties with far more advantage and

profit than he could without it. He is not the slave of any bad habits; his gains therefore are not insensibly creeping away from him. Above all, he has good character; this will give him credit. Habits of industry, frugality, and exactness, will secure, establish, and increase his credit to all the extent he should desire; and give him the command of the property of others. All this, then, is capital—capital of the best kind. A purely monied capital may pass away from him by a thousand contingencies; but this other capital, which I choose to call a moral capital, is under his own control, secure from all the fluctuations and vicissitudes of trade and business, and never can be taken from him without his own consent.

For a young man to be placed at once in the possession of a large monied capital at his setting out in business, though it may be highly gratifying to his vanity, is extremely hazardous to his virtue. I have known in such cases innumerable instances of deplorable failure and bankruptcy. The passion for speculation, over-trading, and extraordinary gains, to which they are excited by the possession of a large monied capital at setting out, leads men into a thousand risks, which they cannot encounter without extreme peril. On the other hand, those habits of care and caution, which small means, and gradual and moderate earnings, beget, are a sure foundation of increase and security.

Large means and extensive speculations, where the possessor has had no lessons in a humbler sphere, nor been compelled by an early and stern necessity to proceed with the greatest caution, almost inevitably lead to habits of wasteful expenditure. "Many estates are spent in the getting." Wealth and accumulation depend as much upon saving as upon gaining.

To say of a young man, therefore, coming into life with health, strength, capacity for labor, a good education, a useful and respectable trade, habits of sobriety and frugality, and above all a good and unsullied character, that he has no capital, is a gross absurdity and error. He has the best of all capital—a moral capital; the noblest of all

power—moral power; he has the most certain means of honest and honorable accumulation and fortune, and may be sure, under circumstances ordinarily propitious, to rise to that competency of influence, respect, and general confidence, and that honorable measure of wealth and independence, which should fully satisfy a reasonable and virtuous ambition. H. C.

The object of giving, in each number of the Companion, the biography of some distinguished *man*, who has arisen from poverty by his own exertions, is to show those who read it the path which leads from poverty and ignorance to wealth, intelligence, and influence; and to induce them, if possible, to adopt that course which, if pursued with ordinary diligence for a few years, will most certainly elevate them to a station in society which they have supposed altogether beyond their reach.

NATHANIEL SMITH.

Nathaniel Smith was born at Woodbury, in the State of Connecticut, on the 6th of January, 1762. He was destitute of the means of an early education, and while yet a youth was actively and successfully engaged in pursuits, in which he discovered such discretion and strength of intellect, as promised future eminence. An incident, of no great importance in itself, induced him to enter upon the study of the profession of law. Having engaged in this pursuit, he persevered in it with surprising constancy of purpose, unappalled by difficulties which ordinary minds would have deemed entirely insurmountable. He studied under the direction of the celebrated Judge, Tapping Reeve, of Litchfield, founder of the law school in that place; and the sound and enlightened guide of many young men, who have become eminent in their profession. Probably no individual, who has lived in this country, has done so much as Judge Reeve, in implanting in the breasts of lawyers the great principles of morality and religion.

Mr. Smith entered the office of Judge Reeve about the close of the war of the revolution, and such was his progress as to afford proof of the soundness of his judgment in the choice of his profession. In 1787, he was admitted to the bar, and his first efforts showed a mind of a superior order. Though surrounded by powerful competitors, he soon rose to distinction, and was pronounced an able advocate.

In 1795, Yale College bestowed on him the honorary degree of Master of Arts, and in the same year he was chosen representative in the Congress of the United States, where he continued four years. On his declining a third election to Congress, he was chosen a member of the Upper House, (or Senate,) of his native State, in which office he was continued, by annual election, for several years. In these various stations, he acquired great respect for his manly eloquence, for his firmness, his political integrity, and his comprehensive views. In October, 1806, he was appointed a Judge of the Supreme Court. This place he accepted at a great pecuniary sacrifice, as thereby he relinquished his lucrative and extensive professional employments. He remained in this important office until May, 1819. Not having had the advantages of early instruction and discipline, his style and manner of speaking showed nothing of the polished refinement of the scholar, but it manifested that which is of far greater value, a mind thoroughly disciplined, acquainted with the subjects on which it was occupied, and intensely engaged in convincing the understandings of his hearers. In his arguments at the bar, in his speeches before deliberative assemblies, and in his opinions on the bench, he discussed nothing but the merits of the question, and here he always appeared, as in truth he was, an able man. His language was not classical, but appropriate—his eloquence was not ornamented, but powerful—it fixed attention, and produced conviction. He never sought to display qualities which he did not possess. He reasoned according to the strict rules of logic, without ever having studied them—he spoke well without any theoretical knowledge of the arts of the rhetorician. To a mind naturally strong and thoroughly disciplined, he added so much knowledge of the technicalities and forms of the law, as enabled him to discern the nature of the questions submitted to him, and with the aid of his own resources, to decide correctly in cases of doubt and difficulty. To obstacles, which could be overcome, he never yielded. The powers of his mind rose with every difficulty, which he had to encounter, and he appeared to be the strongest when sustaining the heaviest weight.

Judge Smith was never a sceptic in religion. He always entertained great regard for Christianity. He had, notwithstanding, doubts respecting the reality of that change which is produced in the hearts of men, by the influence of the Spirit of God. At length, at the age of forty-six years, in the full possession of his understanding, and at a time when his imagination would not lead

him astray, and in the hour of calm and deliberate reflection, he believed that such a change was produced in his own bosom. Under its influence he afterwards lived. His religious impressions were kept, for a time, entirely concealed, even from his most intimate friends. This proceeded, as it is supposed, from an excessive delicacy, as well as from a mistaken sense of duty. Placed as he was in an high and responsible office, and fearing that, in his situation, an avowal of his faith in Christ might be attributed to improper motives, he retained his feelings within his own breast. When his situation in relation to the public became such as to prevent any misconstruction of his motives, he hesitated no longer to profess his belief in religious truth, and his high hopes growing out of it. His trust in the merits and grace of the Redeemer of men, cheered and supported him during the remainder of his days.

He died in calm and blessed expectation of eternal life, at Woodbury, on the 9th of March, 1822, in the sixty-first year of his age.

A LESSON.—The following concise history of a mechanic exhibits in a few words the effects of **INDUSTRY, INTEMPERANCE, and SELF-DENIAL.** Young man, would it not have been better for that man to have continued as he commenced, an industrious and **TEMPERATE** man? How much happiness, (to say nothing of property,) and self-respect, must he have lost, by giving way to vice and drunkenness? And how few, indeed, when once thus lost, ever recover from the depths of infamy to which they often sink. Would you live respected by yourself, as well as by others, *then avoid the DECANTER.*

AN INSTRUCTIVE TALE.

We have seldom heard a tale of human life more instructive than that which we are about to relate. We heard the substance of it related by a friend, and have taken the liberty to throw it into its present shape, and lay it before our readers. It is a fine illustration of what **FRANKLIN** so much insisted on, that industry and temperance are almost certain to lead to independence and comfort.

THOMAS P—, at the age of 18, was, by the death of his master, turned loose upon the world, to gain a livelihood as a shoemaker. He shouldered his kit and went from house to house, making the farmers' leather, or mending their childrens' shoes.

At length a good old man, pleased with Tom's industry and steady habits, offered him a small building as a shop. Here Tom applied himself to work with persevering industry and untiring ardor. Earlier than the sun he was whistling over his work, and his hammer song often was heard till the "noon of night." He thus gained a good reputation, and some of the world's goods. He soon married a virtuous female—one whose kind disposition added new joys to his existence, and whose busy neatness rendered pleasant and comfortable their little tenement. The time passed smoothly on—they were blessed with three smiling pledges of their affection, and in a few years Tom was the possessor of a neat little cottage and a piece of land. This they handsomely improved, and it was evidently the abode of plenty and felicity. But now Tom began to relax from his strict habits, and would occasionally walk down to a tavern in the neighborhood. This soon became a habit; and the habit imperceptibly grew upon him; he became a constant loungee about the tavern, and extremely dissipated. The inevitable consequences soon followed; he got in debt and his creditors soon stripped him of all he had. His poor wife used all the arts of persuasion to reclaim him, and she could not think of using him harshly, for she loved him even in his degradation. Many an earnest petition did she proffer to heaven for his reformation, and often did she endeavor to work upon his parental feelings. He often promised to reform, and was at last induced to stay from a tavern three days together; and his solicitous companion began to cherish hopes of returning happiness. But he could endure no longer. "Betsy," said he, as he arose from his work, "give me the decanter." These words pierced her heart, and seemed to sound the knell of all her cherished hopes; but she could not disobey him. He went to the tavern, and after some persuasion induced the landlord to fill the decanter; he returned and placed it in the window immediately before him: "for," said he, "I can face my enemy."

With a resolution fixed upon overcoming his pernicious habits, he went earnestly to work, always having the decanter before him; he never touched it. Again he began to thrive, and in a few years he was once more the owner of his former delightful residence. His children grew up, and are now respectable members of society. Old age came upon Tom, but he always kept the decanter in the window, where he first put it; and often when his head was silvered over with age, he would refer to his decanter, and laugh at its singular effect; and he never permitted it to be removed

from that window while he lived, nor was it until he had been consigned to his narrow house.

HINTS TO YOUNG MEN, NO. II.

The human life is aptly compared to a journey. In travelling on a frequented road, we pass three classes of people. The first class have no object but momentary gratification; the second profess, at least, to have some particular destination connected with business; the third are neither seeking pleasure nor pursuing business, and are, of course, wanderers and vagrants.

The first of these classes, though not numerous, are sufficiently so to answer our purpose of illustration, or indeed almost any other purpose. They generally appear with great pomposity, borne on some highly respectable agent of locomotion, and surrounded by all the insignia of artificial consequence. Sometimes they acknowledge some ostensible point of destination, such as to visit some great personage, who is a friend of theirs, or a place of fashionable resort, or some great curiosity; and very similar in every respect is the history of these people through life. They have no specific purpose in life to accomplish, except the very useful one of dispersing and distributing a mass of wealth scraped together by their ancestor or ancestors, not always perhaps by means of most scrupulous honesty, and except, also, to display the trappings of their style to the gazing multitude; and these sublime objects can be attained in any place where there are luxuries to be had or fools to gaze at them. They would even feel degraded by the least suspicion of doing any thing which might be of use to mankind. Their profession is to kill time, and their day's work is always done when night overtakes them, unless they see fit to add the night to it.

But it is not for this class of travellers in life's journey that these hints are intended. They would consider them as coming from a class beneath them, and therefore unworthy of their notice. They are designed for the benefit of the second or producing class, which comprehends the principal mass of mankind, and who consider themselves born for some useful purpose, and owing a duty to themselves and the world. These people are in life the travellers on business, or on some specific purpose; and like travellers on a journey, the rate of their progress embraces all degrees, from the most incredible celerity to no celerity at all, and of success, from the summit of prosperity and good fortune, down to an uninterrupted succession of disasters, ending in perfect failure.

But the similitude does not end here. The success of a journey depends, as may be seen by the slightest observation, on the manner of preparation, and the way in which it is pursued. The first point to be considered is the object of the journey, and the place of its location. If, on our consideration, the object is worthy of our attention, and its situation is clearly ascertained, the next point is the roads which lead to it; if there are several, to find out the best. Perhaps one road may be nearest, another smoothest and safest; all which circumstances are to be duly weighed. In the next place, what will be the amount of expenses, and whether we have the funds to meet them. If it is a journey of profit, what will be the nett result; and if of pleasure, will it be worth the time and money it will cost. He who does not pay due attention to all these in setting out on a journey, will probably meet with unforeseen disasters, and with disappointments—perhaps with complete failure, and final ruin.

And precisely in the same ratio is the necessity of carefully weighing and adjusting all these matters in commencing the journey of life. The man who is on a journey without knowing the way, or without any plan, or any precise object in view, may by chance find a bag of money, or some rich treasure, but the chances are millions to one against him; and he who proceeds on the journey of life in the same manner, will find the chances much the same. He may blunder on wealth and respectability, but such blunders are so rare that no man of sense would risk his fate on the hazard.

From all these considerations the conclusion is irresistible, that it is the duty of every man, on arriving at the proper age, to prepare for the business of life; and it is at that time paramount to all other earthly duties, to decide with calm deliberation on the part he is to act in life; and on the manner in which he intends to act it. He ought now to consider himself a member of the human family, possessing all the most valuable rights and privileges, in common and in equal share with every other member. Within the compass of human power, he can be whatever he pleases; and it is equally at his option to decide whether he will be any thing or nothing.

If he has wealth and friends at his command, these are blessings highly to be prized if used with cautious discretion; but they are inseparably connected with temptations and enticements to lead him astray, from which the young man in a state of poverty is wholly exempt. He will be exposed to parasites and sharpers, who, if they do not rob him of his money by fraudulent tricks

and deceptions, will lead him, if he is not duly guarded against them, into scenes of dissipation, which are almost sure to end his course in poverty, if not in disgrace. The possession of wealth will also be apt to make him overrate his estimate of his own value, and give him a haughty and overbearing spirit, which is one of the most serious evils a young man can suffer. But if he listen to the dictates of wisdom and prudence, he will reflect that every human being is his fellow-creature, and that all have an equal right to be treated with equal respect, who have not voluntarily forfeited that right by their own base conduct; but he will form no friendship or intimate connection with any one, whose character will not render that friendship or connection valuable. He will consider that his wealth may forsake him, even without any fault or error of his own; but his moral worth and useful acquirements will not only remain, but they will secure him friends and happiness, even in poverty.

If, on the other hand, a young man be poor, he should consider himself of no less value on that account. He may, some day, exchange circumstances, in that respect, with the richest youth of his acquaintance. This exchange often takes place between the rich and the poor; but between the good and the bad, between the wise and the foolish, the useful and respectable member of society and the worthless vagrant, very seldom, if ever. If he is not only poor, but obscure and friendless, there is no need of his long remaining so. The road to wealth, distinction, and preferment, is equally open to all, and industry and prudence are sure guides, always ready to conduct any one who wishes to travel in it.

Let, then, every young man consider these things with calm and serious attention, and weigh every circumstance with the same interest he would feel if his fate were depending before a legal tribunal. Let him reflect that he is now about to pronounce sentence upon himself, and from that sentence there will be little chance of appeal. That sentence may perhaps decide whether he shall enjoy wealth, reputation, and happiness, or be a miserable vagrant—whether he shall preside on the seat of justice, or be a criminal at the bar. Let him examine his own capacity, and make a due estimate of his talents; and also consult his taste, his predilections and aversions; and when he has duly compared all together, let him decide with firmness on the course he is to pursue,—and having once decided, let that decision be irrevocable.

If his taste accords peculiarly with rural scenery, and he can enjoy and feast his mind on the rich beauties of nature, and es-

pecially of nature improved by art, then agriculture opens to his acceptance a field of enjoyment, perhaps superior to any other pursuit in life. In this he will find ample room for the display of genius, if he has it. Is wealth his object, it has no surer source than agriculture well conducted. If he has caught the dire contagion of political ambition, it will throw no obstacle in his way; and if he possesses an independent mind, here he can sit under the bower of his own raising, and eat the fruit of his own planting, and laugh at the disasters of office-seekers and stockjobbers, and the roarings of the troubled sea of party spirit.

If the bias of his mind turns his inclinations to the useful mechanic arts, in these there is abundant scope for the exercise of genius, and, if combined with industry and prudence, for the acquirement of wealth or fame.

Has he that innate talent and restless curiosity which will prompt and enable him to explore the lofty heights and deep recesses, and trace out the windings of abstract science, or does he aspire to wear the laurels of refined literature, history furnishes a thousand examples to show that poverty or wealth do not amount to a straw in the balance, for or against him. Let him once decide on the path he is to pursue, and the object he aims at, and *prudence* will show him the way, and *industry* will carry him forward to the anticipated mark, and perhaps beyond it.

But if deaf to the voice of reason, and blind to the prospects which lie open before them, the youth of our country will submit to the guidance of "heedless rambling impulse," and embark into the world at random, like a ship at sea without chart or compass; they have only to look on society, and read the history of their own fate in the thousands they can see who have done the same before them, and who are now struggling through embarrassments, or

"shrinking
Into the sordid hut of cheerless poverty;"

perhaps wandering in wretchedness, without home or shelter, or what is still worse, ending their career in infamy or in prison,

"Shut from the common air, and common use
Of their own limbs."

If they will not take warning by these examples staring them daily in the face, they must then take their own course, and "*go and do likewise.*"

But hoping and trusting that many, if not all those who are now coming upon the stage of action, will be governed with more discretion, I shall in the next and succeeding numbers suppose they have made their choice, and adopted the plan of their future

life; and endeavor to give them such hints, adapted, respectively, to the courses they may have chosen, as I have learned from long experience and attentive observation, often under the lash of adversity, and smarting with the sting of disappointment, when, for want of better information, I have strayed from the right path; sincerely hoping that the advice I shall give will enable my young friends to escape the like punishment, and steer a more happy traverse than has marked the fate of

PHILANTHROPOS.

EXTRACT FROM A MANUSCRIPT COPY OF A
FATHER'S ADVICE TO HIS SON.

The most important thing at setting out in life is to make a just estimate of our own worth and talents. If we suffer vanity and self-conceit to overrate our estimate, we render ourselves ridiculous in the eyes of others; and if want of due ambition makes us underrate ourselves, we lessen in proportion our real value, for few people will rate us above our own estimate. By a due estimate of your own value in your intercourse with mankind, you will equally avoid meanly cringing to those you suppose above you, and domineering over those below you, each of which equally speak a little or uncultivated mind.

A certain degree of respect is due to persons of peculiar merit, or who fill elevated stations, but civility is due to every one in life, whose base conduct has not forfeited it. An easy, kind, and pleasing address, without sacrifice of dignity, is among the most valuable acquirements, and is within the reach of every person. It is a kind of current coin, that will pass universally even among savages, and will gain you friends with those who cannot understand your language.

Remember that time and exertions are the only true source from which to gain property, therefore never sacrifice the one, nor neglect the other.

In all your business transactions, the reputation of prudence and perfect honesty will give what control you need of every man's purse; and the easiest way to obtain that reputation is to deserve it.

You have doubtless had, and will still have, many offers of *friendship*; but never suffer yourself to consider any person your friend but whose character will make his friendship valuable. Never displease your friend by any apparent want of confidence; but never let it be in his power to injure you, should he prove perfidious.

In forming your plans of business, listen with attention to the advice of others, especially those of experience, and weigh

every circumstance deliberately in forming your opinions, always reserving to yourself the right of being governed by *your own* opinion, whatever it may be; and when you have settled upon your plan, pursue it in spite of every thing but impossibility, or the discovery that it is morally wrong.

Should you meet, as you doubtless will, with disasters in the pursuits of life, never suffer your mind to be depressed, nor give way to a moment's despondency. Cheerfulness and courage are as necessary to the mind as food is to the body; and remember, under all circumstances, that to despair forms no part of the duty you owe to yourself and to the world.

KNOWLEDGE FOR THE PEOPLE, OR THE PLAIN WHY AND BECAUSE.

(Continued from page 28.)

The velocity of a musket ball is, on an average, 1,600 feet per second, and its range half a mile.

Why is this range only half a mile, whereas, by theory, it ought to be ten miles?

Because it is retarded by the resistance of the air.

In velocities exceeding 1,600 feet per second, the resistance of the air is greatly increased; hence the absurdity of giving balls too great an initial velocity. To give a bullet the velocity of 2000 feet per second, requires half as much more powder as to give it the velocity of 1,600 feet; yet, after both have moved 400 feet, the difference between the velocity of each is reduced to 8 feet per second. A 24-pound ball, moving at the rate of 2000 feet per second, meets a resistance of 800 pounds.

If a body could be projected upwards with the velocity of 36,700 feet in a second, it would never return; and as it receded from the earth, its weight or gravity would diminish. At present, the greatest velocity with which we can project a body, does not exceed 2000 feet per second. A bullet rising a mile above the surface of the earth, loses 1-2000th part of its weight.—[Notes in Science.]

Lieut. Helwig, of Prussia, has invented a process for measuring the time occupied by a ball or bullet in passing through a certain space; by making the ball liberate the works of a time-keeper at the moment when it quits the mouth of the piece, and in making it also stop the time-keeper at the moment when it strikes an obstacle. Thus, he finds that a light body, of the same calibre with the bullet, moves, at the commencement, with much greater velocity than the latter; equal charges being used.

Steam cannon has not yet been found to realize all the formidable expectations which

it had raised; but Mr. Perkins has estimated the projectile force of steam to be ten times greater than that of gunpowder, in throwing a ball to a given distance.

While on the subject of fire-arms, we may mention that an ingenious Frenchman proposes to fix a small mirror, 0.47 of an inch, in the side, near the mouth-piece, so that the person using it shall see the reflection of his own eye. In this way it is supposed that very exact aim may be taken; and the experiments made by various officers and sportsmen are said to encourage the idea that this application may be useful.

Why will a bullet, fired against a door hanging freely on its hinges, perforate the same without agitating it?

Because the impression of the stroke is confined to one single spot, and sufficient time is not allowed for diffusing its action over the extent of the door. A pellet of clay, a bit of tallow, or even a small bag of water, discharged from a pistol, will produce the same effect.

Why is sea-sickness produced on ship-board?

Because man, strictly to maintain his perpendicularity, that is, to keep the centre of gravity always over the support of his body, requires standards of comparison, which he obtains chiefly by the perpendicularity or known position of things about him, as on land; but on shipboard, where the lines of the masts, windows, furniture, &c., are constantly changing, his standards of comparison are soon lost or disturbed. Hence, also, the reason why persons, unaccustomed to the motion of a ship, often find relief by keeping their eyes directed to the fixed shore, where it is visible, or by lying on their backs, and shutting their eyes; and, on the other hand, the ill effects of looking over the side of the vessel at the restless waves of the sea.

Sea-sickness, observes Dr. Arnott, also depends partly on the irregular pressure of the bowels among themselves, and against the containing parts, when their inertia, or downward pressure, varies with the rising and falling of the ship.

Reasoning upon the last-mentioned facts, Mr. Pratt, of New Bond street, has constructed an elastic or swinging seat, couch, or bed, for preventing the uneasy motions of a ship or carriage; the frame of which is suspended on jiribals or joints, turning at right angles to each other; and an elasticity is produced both in the seat or cushion, and in the swinging frames, by the use of spiral metal springs, in the form of an hour-glass. A still more simple preventive was illustrated by Sir Richard Phillips, on his crossing from Dover to Calais, a few years since. He caused an arm-chair to be placed

on the deck of the vessel, and being seated in it, he began to raise himself up and down, as on horseback. The passengers laughed at his eccentricity, but before they reached Calais, many of them were sea-sick, while Sir Richard continued to enjoy his usual health and vigor. We mentioned this experiment whilst making the same passage in the Royal George steam-boat, about a fortnight since; but no person aboard made the trial of its efficacy, although more than half of the number were sea-sick.

An embrocation has lately been invented, and secured by patent, for preventing or alleviating sea-sickness; this preparation is to be rubbed over the lower end of the breast-bone, and under the left ribs; but we cannot add our own testimony of its efficacy.

Why cannot sure aim be taken with a stone in a sling?

Because the point from which it should depart cannot be accurately determined.

Why is the pendulum a time-keeper?

Because the times of the vibrations are very nearly equal, whether it be moving much or little; that is to say, whether the arc described by it be large or small.

A common clock is merely a pendulum, with wheel-work attached to it, to record the number of the vibrations; and with a weight or spring, having force enough to counteract the retarding effects of friction and the resistance of the air. The wheels show how many swings or beats of the pendulum have taken place, because at every beat, a tooth of the last wheel is allowed to pass. Now, if this wheel has sixty teeth, as is common, it will just turn round once for sixty beats of the pendulum, or seconds; and a hand fixed on its axis, projecting through the dial-plate, will be the second hand of the clock. The other wheels are so connected with this first, and the numbers of the teeth on them so proportioned, that one turns sixty times slower than the first, to fit its axis to carry a minute hand; and another, by moving twelve times slower still, is fitted to carry an hour hand.—[Arnott.]

Why do clocks denote the progress of time?

Because they count the oscillations of a pendulum; and by that peculiar property of the pendulum, that one vibration commences exactly where the last terminates, no part of time is lost or gained in the juxtaposition (or putting together) of the units so counted, so that the precise fractional part of a day can be ascertained which each such unit measures.

The origin of the pendulum is traced to Galileo's observation of a hanging lamp in a church at Pisa continuing to vibrate long

and with singular uniformity, after any accidental cause of disturbance. Hence he was led to investigate the laws of the phenomenon, and out of what, in some shape or other, had been before men's eyes from the beginning of the world, his powerful genius extracted the most important result.

The invention of pendulum clocks took place about the middle of the seventeenth century; and the honor of the discovery is disputed between Galileo and Huygens. Becher contends for Galileo, and states that one Trifler made the first pendulum clock at Florence, under the direction of Galileo Galilei, and that a model of it was sent to Holland. The Accademia del Cimento also expressly declared, that the application of the pendulum to the movement of a clock was first proposed by Galileo, and put in practice by his son, Vincenzo Galileo, in 1649. Huygens, however, contests the priority, and made a pendulum clock before 1658; and he insists, that if ever Galileo had entertained such an idea, he never brought it to perfection. Beckmann says the first pendulum clock made in England was constructed in the year 1662, by one Tromantil, a Dutchman; but Grignon affirms that the first pendulum clock was made in England, by Robert Harris, in 1641, and erected in Inigo Jones's church of St. Paul, Covent-garden.

Why does the pendulum move faster in proportion as its journey is longer?

Because, in proportion as the arc described is more extended, the steeper are its beginning and ending; and the more rapidly, therefore, the pendulum falls down at first, sweeps along the intermediate space, and stops at last.—[Arnott.]

Why is it extremely difficult to ascertain the exact length of the pendulum?

Because of the various expansion of metals, respecting which no two pyrometers agree; the changeable nature of the atmosphere; the uncertainty as to the true level of the sea; the extreme difficulty of measuring accurately the distance between the point of suspension and the centre of oscillation, and even of finding that centre; also the variety of terrestrial attraction, from which cause the motions of the pendulum are also liable to variation, even in the same latitude. In pursuing his researches, Capt. Kater discovered that the motions of the pendulum are affected by the nature of the strata over which it vibrates.

Why does the force of gravity determine how long the pendulum shall be in falling to the bottom of its arc, and how long in rising?

Because the ball of the pendulum may be considered as a body descending by its weight on a slope; a change in the force of

gravity, therefore, would at once alter the rates of all the clocks on earth.—[Arnott.]

Why is the regulator of a watch merely a pin which bears against the balance-spring?

Because it slides backwards and forwards, so as to shorten or lengthen the part of the spring left free to bend, thus changing the degree of its stiffness; and, as the motion of the pendulum has relation to the force of gravity, so has the motion of the balance-wheel to the stiffness of the balance-spring.

[From the American Journal of Science and Arts.]

DIVISIBILITY OF MATTER.

Hanover, N. H., Dec. 18, 1834.

To Professor Silliman—

Dear Sir: There has been, as we well know, much labored discussion, and much waste of ink, upon the subject of the divisibility of matter. As the following has a bearing upon that point, and may be considered as a striking illustration of it, and as the result of my calculations was not a little surprising, as well as amusing to myself, and may be so to others, I send it to you, that you may, if you think fit, give it a place in your valuable Journal.

Several years since, as I was setting by my fireside, I observed several of my family around a table, reading by the light of a single candle. The thought occurred—how great a portion of the light of that candle is used by those several persons reading? And then immediately, a second thought—for how many persons does that candle furnish light sufficient to enable them to read, provided it could be so distributed that the whole should be used for that purpose without any loss? The candle was rather a large one, and gave a very clear, bright light. I found on trial, that I could read very well with my book at the distance of three feet from the candle, and with my eyes nine inches from the book. The candle then would illuminate the concave surface of a sphere of three feet radius sufficiently for the purpose of reading. By measuring, I found that the book I made use of contained on an average twenty letters to an inch, and ten lines to an inch. But as the spaces between the lines were broader than the lines themselves, instead of ten, I supposed twenty lines to an inch, and, consequently, that four hundred letters would be contained in a square inch. A concave sphere then of six feet diameter would contain six million five hundred and fourteen thousand and four hundred letters. This number of letters the candle would illuminate, so that each would be distinctly visible to an eye at the distance of nine inches. Here I would just observe, that the

candle was supposed to be so philosophically made, that, whilst it maintained a constant bright flame, it did not intercept its light from a single letter in the concave sphere.

Again, the light, reflected from a single letter, would render that letter visible to an eye at the distance of nine inches, not in one direction only, but to an eye placed any where in the concave surface of a hemisphere of nine inches radius. To how many eyes, then, is the light reflected from one letter, sufficient to render it visible?

I supposed the pupil of the eye to be one eighth of an inch in diameter, which is probably near the truth. On this supposition, the surface of a hemisphere of nine inches radius is equal to the pupils of forty one thousand four hundred and sixty-five eyes. To this number of eyes, or to half this number of pairs of eyes, the light reflected from a single letter is sufficient to render that letter distinctly visible. But here it may be objected, and it is true, that to an eye, placed near the plane of the leaf, a sufficiency of light would not be reflected. But it is also unquestionably true, that not half the light which falls upon the leaf is reflected. The light, therefore, which is absorbed, would much more than compensate for this deficiency.

Now, the light which falls upon a single letter being sufficient to render it visible to 20,732 pairs of eyes, and the number of letters in the concave surface of a sphere of three feet radius being 6,514,400, the light which falls upon all these letters is sufficient for 135,056,540,800 pairs of eyes,—or the light of one candle, should not a particle be lost, and the whole be so distributed, that each should receive his equal portion, is sufficient to enable 135,056,540,800 persons to read at the same time. If our earth contains 900,000,000 of inhabitants, and that, I believe, is the highest supposition ever made, the light of one candle is more than sufficient to enable all the inhabitants of one hundred and fifty such worlds to be reading at the same instant. This conclusion, I am aware, will appear to many, perhaps to most, altogether incredible; but any one, possessing but a moderate share of mathematical knowledge, may in a short time easily satisfy himself, that, rejecting fractions, it is rigidly exact.

A candle, like that to which I have referred, would undoubtedly continue burning at least four hours. What quantity of light then, to be determined either by weight, measure, or the number of particles, will suffice for one person to read for one minute?

It will readily be perceived, that I have proceeded upon the supposition that the Newtonian theory of light is correct.

E. ADAMS.

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